Flood Risk Report

City of Virginia Beach, Virginia Coastal Study

County: N/A

Community Names: City of Virginia Beach Independent City

State: Virginia

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FEMA

RiskMAP

Increasing Resilience Together

Preface

The Department of Homeland Security (DHS), Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program provides states, tribes, and local communities with flood risk information and tools that they can use to increase their resilience to flooding and better protect their citizens. By pairing accurate floodplain maps with risk assessment tools and planning and outreach support, Risk MAP has transformed traditional flood mapping efforts into an integrated process of identifying, assessing, communicating, planning for, and mitigating flood-related risks.

This Flood Risk Report (FRR) provides non-regulatory information to help local or tribal officials, floodplain managers, planners, emergency managers, and others better understand their flood risk, take steps to mitigate those risks, and communicate those risks to their citizens and local businesses.

Because flood risk often extends beyond community limits, the FRR provides flood risk data for the entire Flood Risk Project as well as for each individual community. This also emphasizes that flood risk reduction activities may impact areas beyond jurisdictional boundaries.

Flood risk is always changing, and there may be other studies, reports, or sources of information available that provide more comprehensive information. The FRR is not intended to be regulatory or the final authoritative source of all flood risk data in the project area. Rather, it should be used in conjunction with other data sources to provide a comprehensive picture of flood risk within the project area.

Table of Contents

1 Introduction 1
1.1 About Flood Risk 1
1.1.1 Calculating Flood Risk 1
1.1.2 Flood Risk Products 2
1.2 Uses of this Report 2
1.3 Sources of Flood Risk Assessment Data Used 4
1.4 Related Resources 4
2 Flood Risk Analysis 6
2.1 Overview 6
2.2 Analysis of Risk 6
2.2.1 Changes Since Last FIRM 7
2.2.2 Flood Depth and Analysis Grids 8
2.2.3 Flood Risk Assessments 9
2.2.4 Areas of Mitigation Interest 11
3 Flood Risk Analysis Results 19
3.1 Flood Risk Map 21
3.2 City of Virginia Beach, Virginia Coastal Study Summary 23
3.2.1 Overview 23
3.2.2 Flood Risk Datasets 24
4 Actions to Reduce Flood Risk 29
4.1 Types of Mitigation Actions 29
4.1.1 Preventative Measures 29
4.1.2 Property Protection Measures 30
4.1.3 Natural Resource Protection Activities 30
4.1.4 Structural Mitigation Projects 30
4.1.5 Public Education and Awareness Activities 31
4.1.6 Emergency Service Measures 31
4.2 Identifying Specific Actions for Your Community 31
4.3 Mitigation Programs and Assistance 32
4.3.1 FEMA Mitigation Programs and Assistance 33

4.3.2 Additional Mitigation Programs and Assistance....34
5 Acronyms and Definitions....35
5.1 Acronyms....35
5.2 Definitions....36
6 Additional Resources....40
7 Data Used to Develop Flood Risk Products....43

List of Tables

Table 3-1: City of Virginia Beach, Virginia: Estimated Potential Losses for Flood Event Scenarios....28
Table 4-1: FEMA Hazard Mitigation Assistance Programs....33

FLOOD RISK REPORT

1 Introduction

1.1 About Flood Risk

Floods are naturally occurring phenomena that can and do happen almost anywhere. In its most basic form, a flood is an accumulation of water over normally dry areas. Floods become hazardous to people and property when they inundate an area where development has occurred, causing losses. Mild flood losses may have little impact on people or property, such as damage to landscaping or the generation of unwanted debris. Severe flooding can destroy buildings, ruin crops, and cause critical injuries or death.

Flooding is a natural part of our world and our communities. Flooding becomes a significant hazard, however, when it intersects with the built environment.

1.1.1 Calculating Flood Risk

It is not enough to simply identify where flooding may occur. Just because one knows where a flood occurs does not mean they know the **risk** of flooding. The most common method for determining flood risk, also referred to as vulnerability, is to identify the probability of flooding and the consequences of flooding. In other words:

Flood Risk = Probability x Consequences; where

- **Probability** = the likelihood of occurrence
- **Consequences** = the estimated impacts associated with the occurrence

The probability of a flood is the likelihood that a flood will occur. The probability of flooding can change based on physical, environmental, and/or contributing engineering factors. Factors affecting the probability that a flood will impact an area range from changing weather patterns to the existence of mitigation projects. The ability to assess the probability of a flood and the level of accuracy for that assessment are also influenced by modeling methodology advancements, better knowledge, and longer periods of record for the water body in question.

The consequences of a flood are the estimated impacts associated with the flood occurrence. Consequences relate to humans' activities within an area and how a flood impacts the natural and built environments.

Which picture below shows more flood risk?

Even if you assume that the flood in both pictures was the same probability—let's say a 10-percent-annual-chance flood—the consequences in terms of property damage and potential injury as a result of the flood in the bottom picture are much more severe. Therefore, the flood risk in the area shown in the bottom picture is higher.

1.1.2 Flood Risk Products

Through Risk MAP, FEMA provides communities with updated Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study (FIS) Reports that focus on the probability of floods and that show where flooding may occur as well as the calculated 1-percent-annual-chance flood elevation. The 1-percent-annual-chance flood, also known as the base flood, has a 1% chance of being equaled or exceeded in any given year. FEMA understands that flood risk is dynamic—that flooding does not stop at a line on a map—and as such, provides the following flood risk products:

Whether or not an area might flood is one consideration. The extent to which it might flood adds a necessary dimension to that understanding.

- **Flood Risk Report (FRR)**: The FRR presents key risk analysis data for the Flood Risk Project.
- **Flood Risk Map (FRM)**: Like the example found in Section 3.1 of this document, the FRM shows a variety of flood risk information in the project area. More information about the data shown on the FRM may be found in Section 2 of this report.
- **Flood Risk Database (FRD)**: The FRD is in Geographic Information System (GIS) format and houses the flood risk data developed during the course of the flood risk analysis that can be used and updated by the community. After the Flood Risk Project is complete, this data can be used in many ways to visualize and communicate flood risk within the Flood Risk Project.

These Flood Risk Products provide flood risk information at both the Flood Risk Project level and community level (for those portions of each community within the Flood Risk Project). They demonstrate how decisions made within a Flood Risk Project can impact properties downstream, upstream, or both. Community-level information is particularly useful for mitigation planning and emergency management activities, which often occur at a local jurisdiction level.

1.2 Uses of this Report

The goal of this report is to help inform and enable communities and tribes to take action to reduce flood risk. Possible users of this report include:

Vulnerability of infrastructure is another important consideration.

- Local elected officials
- Floodplain managers
- Community planners
- Emergency managers
- Public works officials
- Other special interests (e.g., watershed conservation groups, environmental awareness organizations, etc.)

State, local, and tribal officials can use the summary information provided in this report, in conjunction with the data in the FRD, to:

- **Update local hazard mitigation plans.** As required by the 2000 Federal Stafford Act, local hazard mitigation plans must be updated at least every five (5) years. Summary information presented in Section 3 of this report and the FRM can be used to identify areas that may need additional focus when updating the risk assessment section of a local hazard mitigation plan. Information found in Section 4 pertains to the different mitigation techniques and programs and can be used to inform decisions related to the mitigation strategy of local plans.
- **Update community comprehensive plans.** Planners can use flood risk information in the development and/or update of comprehensive plans, future land use maps, and zoning regulations. For example, zoning codes may be changed to better provide for appropriate land uses in high-hazard areas.
- **Update emergency operations and response plans.** Emergency managers can identify low-risk areas for potential evacuation and sheltering and can help first responders avoid areas of high-depth flood water. Risk assessment results may reveal vulnerable areas, facilities, and infrastructure for which planning for continuity of operations plans (COOP), continuity of government (COG) plans, and emergency operations plans (EOP) would be essential.

Flooding along the Wabash River in Clark County, Illinois, contributed to a federal disaster declaration on June 24, 2008.

- **Develop hazard mitigation projects.** Local officials (e.g., planners and public works officials) can use flood risk information to re-evaluate and prioritize mitigation actions in local hazard mitigation plans.
- **Communicate flood risk.** Local officials can use the information in this report to communicate with property owners, business owners, and other citizens about flood risks, changes since the last FIRM, and areas of mitigation interest. The report layout allows community information to be extracted in a fact sheet format.
- **Inform the modification of development standards.** Floodplain managers, planners, and public works officials can use information in this report to support the adjustment of development standards for certain locations. For example, heavily developed areas tend to increase floodwater runoff because paved surfaces cannot absorb water, indicating a need to adopt or revise standards that provide for appropriate stormwater retention.

The Flood Risk Database, Flood Risk Map, and Flood Risk Report are “non-regulatory” products. They are available and intended for community use but are neither mandatory nor tied to the regulatory development and insurance requirements of the National Flood Insurance Program (NFIP). They may be used as regulatory products by communities if authorized by state and local enabling authorities.

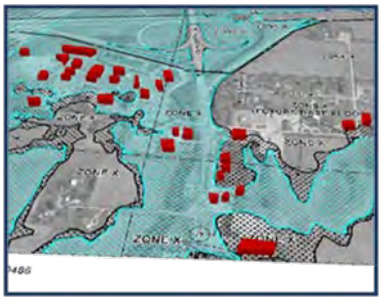
1.3 Sources of Flood Risk Assessment Data Used

To assess potential community losses, or the consequences portion of the "risk" equation, the following data is typically collected for analysis and inclusion in a Flood Risk Project:

- Information about local assets or resources at risk of flooding
- Information about the physical features and human activities that contribute to that risk
- Information about where the risk is most severe

For most Flood Risk Projects, FEMA uses the following sources of flood risk information to develop this report:

- Hazus-estimated flood loss information
- Total Exposure in Floodplain (TEIF)
- New engineering analyses (e.g., coastal, hydrologic, and/or hydraulic modeling) to develop new flood boundaries
- Locally supplied data (see Section 7 for a description)
- Sources identified during the Discovery process



FEMA data can be leveraged to identify and measure vulnerability by including local building information (i.e. building type). The examples above show various ways to display flooding intersecting with buildings.

1.4 Related Resources

For a more comprehensive picture of flood risk, FEMA recommends that state and local officials use the information provided in this report in conjunction with other sources of flood risk data, such as those listed below.

- **FIRMs and FIS Reports.** This information indicates areas with specific flood hazards by identifying the limit and extent of the 1-percent-annual-chance floodplain and the 0.2-percent-annual-chance floodplain. FIRMs and FIS Reports do not identify all floodplains in a Flood Risk Project. The FIS Report includes summary information regarding other frequencies of flooding, as well as flood profiles for riverine sources of flooding. In rural areas and areas for which flood hazard data are not available, the 1-percent-annual-chance floodplain may not be identified. In addition, the 1-percent-annual-chance floodplain may not be identified for flooding sources with very small drainage areas (less than 1 square mile).
- **Total Exposure in Floodplain (TEIF) Loss Estimation Database.** This tool ranks each community in the project area by its total potential economic losses in the special flood hazard area, and geospatially associates those losses, aggregated to each Census

block. The economic losses are estimates, derived from national level datasets – 2010 Census and Americal Community Survey (ACS) data applying 2012 RS Means valuations -- and should be used for relative comparison of potential losses and risk. The National Flood Hazard Layer that was used to develop TEIF was extracted in May 2013. This tool can help to identify areas and populations of highest risk, prioritize hazard mitigation projects and inform resource allocation for pre-disaster planning (FEMA, 2013).

- **Hazus Flood Loss Estimation Reports.** Hazus can be used to generate reports, maps and tables on potential flood damage that can occur based on new/proposed mitigation projects or future development patterns and practices. Hazus can also run specialized risk assessments, such as what happens when a dam or levee fails. Flood risk assessment tools are available through other agencies as well, including the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE). Other existing watershed reports may have a different focus, such as water quality, but may also contain flood risk and risk assessment information. See Section 6 for additional resources.

- **Flood or multi-hazard mitigation plans.** Local hazard mitigation plans include risk assessments that contain flood risk information and mitigation strategies that identify community priorities and actions to reduce flood risk. This report was informed by any existing mitigation plans in the Flood Risk Project.

- **Hurricane Evacuation Studies.** Produced through a joint effort by FEMA, NOAA, and USACE, Hurricane Evacuation Studies provide tools and information to the state and county emergency management offices to help determine who should evacuate during hurricane threats, and when those evacuations should occur. The information can be used to supplement or update hurricane evacuation plans and operational procedures for responding to hurricane threats.

- **Climate Change and Sea Level Rise Data and Maps.** Data and maps showing potential impacts from sea level rise provide a valuable resource for planning and risk communication purposes. By identifying areas that are most susceptible to rising sea levels, short- and long-term strategies can be developed to support coastal communities in their mitigation efforts. Various organizations, including NOAA and State and Local agencies, provide viewers, maps, and/or reports that help highlight low-lying coastal areas that would be inundated based on sea level rise scenarios.

- **Emergency Action Plans.** Emergency Action Plans are formal documents that identify potential emergency conditions at a dam and specify preplanned actions to be followed to minimize property damage and loss of life. The plans specify actions the dam owner should take to moderate or alleviate the identified problems at the dam. These plans usually contain inundation maps downstream of the dam to show emergency management authorities critical areas for action in case of an emergency.

- **FEMA Map Service Center (MSC).** The MSC has useful information, including fly sheets, phone numbers, data, etc. Letters of Map Change are also available through the MSC. The user can view FIRM databases and the National Flood Hazard Layer (NFHL) Database.

2 Flood Risk Analysis

2.1 Overview

Flood hazard identification uses FIRMs, and FIS Reports identify where flooding can occur along with the probability and depth of that flooding. Flood risk assessment is the systematic approach to identifying how flooding impacts the environment. In hazard mitigation planning, flood risk assessments serve as the basis for mitigation strategies and actions by defining the hazard and enabling informed decision making. Fully assessing flood risk requires the following:

- Identifying the flooding source and determining the flood hazard occurrence probability
- Developing a complete profile of the flood hazard including historical occurrence and previous impacts
- Inventorying assets located in the identified flood hazard area
- Estimating potential future flood losses caused by exposure to the flood hazard area

Flooding impacts non-populated areas too, such as agricultural lands and wildlife habitats.

Flood risk analyses are different methods used in flood risk assessment to help quantify and communicate flood risk. Flood risk analysis can be performed on a large scale (state, community) level and on a very small scale (parcel, census block). Advantages of large-scale flood risk analysis, especially at the watershed level, include identifying how actions and development in one community can affect areas up- and downstream. On the parcel or census block level, flood risk analysis can provide actionable data to individual property owners so they can take appropriate mitigation steps.

2.2 Analysis of Risk

The FRR, FRM, and FRD contain a variety of flood risk analysis information and data to help describe and visualize flood risk within the project area. Depending on the scope of the Flood Risk Project for this project area, this information may include some or all of the following elements:

- Changes Since Last FIRM
- Flood Depth and Analysis Grids
- Flood Risk Assessments
- Areas of Mitigation Interest

State and Local Hazard Mitigation Plans are required to have a comprehensive all-hazard risk assessment. The flood risk analyses in the FRR, FRM, and FRD can inform the flood hazard portion of a community's or state's risk assessment. Further, data in the FRD can be used to develop information that meets the requirements for risk assessments as it relates to the hazard of flood in hazard mitigation plans.

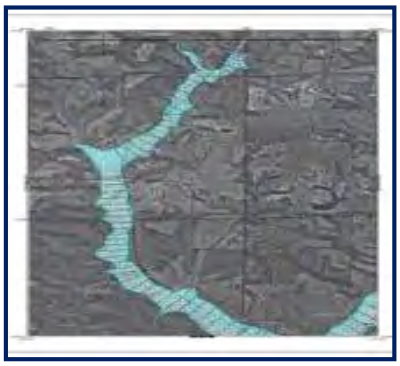
2.2.1 Changes Since Last FIRM

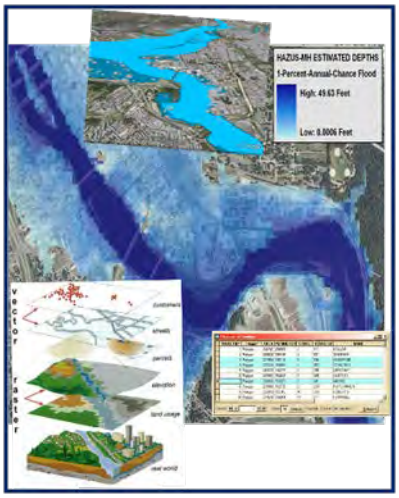
The Changes Since Last FIRM (CSLF) dataset, stored in the FRD and shown in Section 3 of this report, illustrates where changes to flood risk may have occurred since the last FIRM published for the subject area. Communities can use this information to update their mitigation plans, specifically quantifying "what is at risk" and identifying possible mitigation activities.

The CSLF dataset identifies changes in the Special Flood Hazard Area (SFHA) and floodway boundary changes since the previous FIRM was developed. These datasets quantify land area increases and decreases to the SFHA and floodway, as well as areas where the flood zone designation has changed (e.g., Zone A to AE, AE to VE, shaded Zone X protected by levee to Zone AE for de-accredited levees).

The CSLF dataset is created in areas that were previously mapped using digital FIRMs. The CSLF dataset for this project area includes:

- **Floodplain and/or Floodway Boundary Changes**: Any changes to the existing floodplain or floodway boundaries are depicted in this dataset
- **Floodplain Designation Changes**: This includes changed floodplain designations (e.g., Zone A to Zone AE).
- **Coastal High Hazard Changes**: This includes any floodplains that were formerly Zone A, AE or X that are now coastal high hazard zones (e.g., Zone V or VE).
- **Additional Change Information:** Within this dataset additional information is provided to help explain the floodplain and floodway boundary changes shown on the FIRM. This information is stored as digital attributes within the CSLF polygons and may include some or all of the following:
    - Changes in peak discharges
    - Changes to the modeling methodology (e.g., tide gage analysis)
    - New flood control structures (e.g., dams, levees, etc.)
    - Changes to hydraulic structures (e.g., bridges, culverts, etc.)
    - Sedimentation and/or Erosion





Floodplain maps have evolved considerably from the older paper-based FIRMs to the latest digital products and datasets.

CSLF data can be used to communicate changes in the physical flood hazard area (size, location) as part of the release of new FIRMs. It can also be used in the development or update of hazard mitigation plans to describe changes in hazard as part of the hazard profile.

CSLF data is shown in the FRR, and underlying data is stored in the FRD.

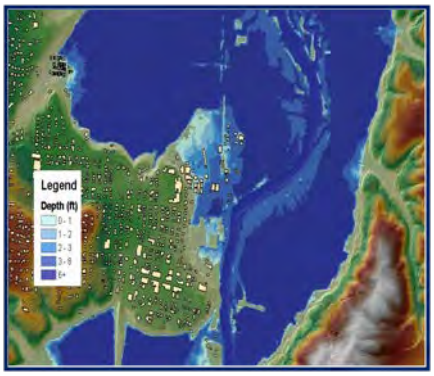
- Man-made changes to a watercourse (e.g., realignment or improvement)

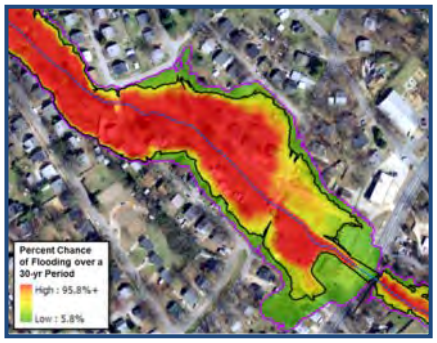
Please note that the reasons for the floodplain and floodway changes (also known as Contributing Engineering Factors) are provided to give the user a general sense of what caused the change, as opposed to providing a reason for each and every area of change.

- **Count of Affected Structures:** The total estimated count of affected buildings within the area of change. The data is only made available because the local jurisdiction was able to provide accurate building footprint data indicating the location of structures in and adjacent to the identified floodplains.

2.2.2 Flood Depth and Analysis Grids

Grids are FEMA datasets provided in the FRD to better describe the risk of the flood hazard. Much like the pixels in a photo or graphic, a grid is made up of square cells, where each grid cell stores a value representing a particular flood characteristic (elevation, depth, velocity, etc.) While the FIRM and FIS Report describe "what" is at risk by identifying the hazard areas, water surface, flood depth, and other analysis grids can help define "how bad" the risk is within those identified areas. These grids are intended to be used by communities for additional analysis, enhanced visualization, and communication of flood risks for hazard mitigation planning and emergency management. The Flood Depth and Analysis Grids provide an alternative way to visualize how a particular flood characteristic (depth, velocity, etc.) vary within the floodplain. Since they are derived from the engineering modeling results, they are typically associated with a particular frequency-based flooding event (e.g., 1-percent-annual-chance event). Grids provided in the FRD for this project area include the following:





Grid data can make flood mapping more informative. The top image is a flood depth grid showing relative depths of water in a scenario flood event. The bottom image is a percent annual chance of flooding grid, which shows inundation areas of various frequency floods.

- **Water Surface Elevation Grids (for the calculated flood frequencies included in the FIS Report):** This dataset represents the flood elevations calculated for each modeled flood frequency.
- **Flood Depth Grids (for the calculated flood frequencies included in the FIS Report):** Flood Depth Grids are created for each flood frequency calculated during the course of a Flood Risk Project. These grids communicate flood depth as a function of the difference between the calculated water surface elevation and the ground. Five grids will normally be delivered for riverine areas for the standard flood frequencies (10-, 4-, 2-, 1-, and 0.2-percent-annual-chance).

Coastal flood depth grids are created for areas where the dominant wave hazard is overland wave propagation. The grid depicts the difference in elevation between the wave crest elevation, or BFE, and the ground. Coastal areas will typically only receive a depth grid for the 1-percent-annual-chance (base) flood for which overland wave propagation results are produced as a part of the FIS; however, approximate methods may be used to estimate wave crest elevations for other flood frequencies, if desired.

Depth grids form the basis for refined flood risk assessments (as presented in a table in Section 3 of this report) and are used to calculate potential flood losses for display on the FRM and for tabular presentation in this report. Depth grids may also be used for a variety of ad-hoc risk visualization and mitigation initiatives.

Grid data can be used to communicate the variability of floodplains, such as where floodplains are particularly deep or hazardous, where residual risks lie behind levees, and where losses may be great after a flood event. For mitigation planning, grid data can inform the hazard profile and vulnerability analysis (what is at risk for different frequencies) and can be used for preliminary benefit-cost analysis screening. For floodplain management, higher regulatory standards can be developed in higher hazard flood prone areas (i.e., 10-percent-annual-chance floodplains or deep floodplains).

Grid data is stored in the FRD, and a list of available grid data is provided in the FRR.

2.2.3 Flood Risk Assessments

Flood risk assessment results reported in the FRR were developed using Hazus, a FEMA flood loss estimation tool. Hazus (www.fema.gov/hazus) is a nationally-applicable and standardized risk assessment tool that estimates potential losses from earthquakes, floods, and hurricanes. It uses GIS technology to estimate physical, economic, and social impacts of disasters. Files from the FRD can be imported into Hazus to develop other risk assessment information including:

Hazus is a loss estimation methodology developed by FEMA for flood, wind, and earthquake hazards. The methodology and data established by Hazus can also be used to study other hazards.

- Debris generated after a flood event
- Dollar loss of the agricultural products in a study region
- Utility system damages in the region
- Vehicle loss in the study region
- Damages and functionality of lifelines such as highway and rail bridges, potable water, and wastewater facilities

Some benefits of using TEIF or Hazus include the following:

- Help individuals and communities graphically visualize the areas where flood risk is highest.
- Outputs that can enhance state and local mitigation plans and help screen for cost-effectiveness in FEMA mitigation grant programs

- Analysis refinement through updating inventory data and integrating data produced using other flood models
- Widely available support documents and networks (Hazus Users Groups)

HAZUS Flood Loss Estimates:

HAZUS loss estimates should be used to understand relative risk from flood and potential losses. Uncertainties are inherent in any loss estimation methodology, arising in part from approximations and simplifications that are necessary for a comprehensive analysis (e.g., incomplete inventories, demographics, or economic parameters).

Flood loss estimates can include the following:

- **Residential Asset Loss**: These include direct building losses (estimated costs to repair or replace the damage caused to the building) for all classes of residential structures including single family, multi-family, manufactured housing, group housing, and nursing homes. This value also includes content losses.
- **Commercial Asset Loss**: These include direct building losses for all classes of commercial buildings including retail, wholesale, repair, professional services, banks, hospitals, entertainment, and parking facilities. This value also includes content and inventory losses.
- **Other Asset Loss**: This includes losses for facilities categorized as industrial, agricultural, religious, government, and educational. This value also includes content and inventory losses.
- **Business Disruption**: This includes the losses associated with the inability to operate a business due to the damage sustained during the flood. Losses include inventory, income, rental income, wage, and direct output losses, as well as relocation costs.
- **Annualized Losses**: Annualized losses are calculated using Hazus by taking losses from multiple events over different frequencies and expressing the long-term average by year. This factors in historic patterns of frequent smaller floods with infrequent but larger events to provide a balanced presentation of flood damage.
- **Loss Ratio:** The loss ratio expresses the scenario losses divided by the total building value for a local jurisdiction and can be a gage to determine overall community resilience as a result of a scenario event. For example, a loss ratio of 5 percent for a given scenario would indicate that a local jurisdiction would be more resilient and recover more easily from a given event, versus a loss ratio of 75 percent which would indicate widespread losses. An annualized loss ratio uses the annualized loss data as a basis for computing the ratio. Loss ratios are not computed for business disruption.

2.2.4 Areas of Mitigation Interest

Many factors contribute to flooding and flood losses. Some are natural, and some are not. In response to these risks, there has been a focus by the Federal government, State agencies, and local jurisdictions to mitigate properties against the impacts of flood hazards so that future losses and impacts can be reduced. An area identified as an Area of Mitigation Interest (AoMI) is an important element of defining a more comprehensive picture of flood risk and mitigation activity in a watershed, identifying target areas and potential projects for flood hazard mitigation, encouraging local collaboration, and communicating how various mitigation activities can successfully reduce flood risk.

This report and the FRM may include information that focuses on identifying Areas of Mitigation Interest that may be contributing (positively or negatively) to flooding and flood losses in the Flood Risk Project. AoMIs are identified through coordination with local stakeholders; through revised hydrologic and hydraulic and/or coastal analyses; by leveraging other studies or previous flood studies; from community mitigation plans, floodplain management plans, and local surveys; and from the mining of federal government databases (e.g., flood claims, disaster grants, and data from other agencies). Below is a list of the types of Areas of Mitigation Interest; however, Areas of Mitigation Interest are not provided in this project.

- **Dams**

  A dam is a barrier built across a waterway for impounding water. Dams vary from impoundments that are hundreds of feet tall and contain thousands of acre-feet of water (e.g., Hoover Dam) to small dams that are a few feet high and contain only a few acre-feet of water (e.g., small residential pond). “Dry dams,” which are designed to contain water only during floods and do not impound water except for the purposes of flood control, include otherwise dry land behind the dam.

  Dams vary in size and shape, the amount of water they impound, and their assigned hazard classification.

  While most modern, large dams are highly engineered structures with components such as impervious cores and emergency spillways, most smaller and older dams are not. State dam safety programs emerged in the 1960s, and the first Federal Guidelines for Dam Safety were not prepared until 1979. By this time, the vast majority of dams in the United States had already been constructed.

  - **Reasons dams are considered AoMIs:**
    - Many older dams were not built to any particular standard and thus may not withstand extreme rainfall events. Older dams in some parts of the country are made out of an assortment of materials. These structures may not have any capacity to release water and could be overtopped, which could result in catastrophic failure.

- Dams may not always be regulated, given that the downstream risk may have changed since the dam was constructed or since the hazard classification was determined. Years after a dam is built, a house, subdivision, or other development may be constructed in the dam failure inundation zone downstream of the dam. Thus, a subsequent dam failure could result in downstream consequences, including property damage and the potential loss of life. Since these dams are not regulated, it is impossible to predict how safe they are.

This dam failure caused flooding that damaged several homes and vehicles.

- A significant dam failure risk is structural deficiencies associated with older dams that are not being adequately addressed today through needed inspection/maintenance practices.
- For larger dams a flood easement may have been obtained on a property upstream or downstream of the dam. However, there may have been buildings constructed in violation of the flood easement.
- When a new dam is constructed, the placement of such a large volume of material in a floodplain area (if that is the dam location) will displace flood waters and can alter how the watercourse flows. This can result in flooding upstream, downstream, or both.
- For many dams, the dam failure inundation zone is not known. Not having knowledge of these risk areas could lead to unprotected development in these zones.

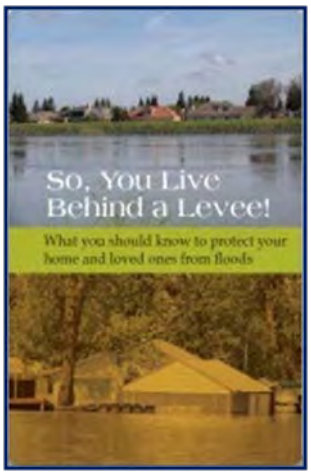
- **Levees**

  FEMA defines a levee as “a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.” Levees are sometimes referred to as dikes. Soil used to construct a levee is compacted to make the levee as strong and stable as possible. To protect against erosion and scouring, levees can be covered with everything from grass and gravel to harder surfaces like stone (riprap), asphalt, or concrete.

  Similar to dams, levees have not been regulated in terms of safety and design standards until relatively recently. Many older levees were constructed in a variety of ways, from a farmer piling dirt along a stream to prevent nuisance flooding to levees made out of old mining spoil material. As engineered structures, levees are designed to a certain height and can fail if a flood event is greater than anticipated.

A floodwall is a vertical wall that is built to reduce the flood hazard in a similar manner as a levee. Typically made of concrete or steel, floodwalls often are erected in urban locations where there is not enough room for a levee. Floodwalls are sometimes constructed on a levee crown to increase the levee's height.

Most new dams and levees are engineered to a certain design standard. If that design is exceeded, they could be overtopped and fail catastrophically, causing more damage than if the levee was not there in the first place. Few levees anywhere in the nation are built to more than a 1-percent-annual-chance flood, and the areas behind them are still at some risk for flooding. In some states, the flooding threat can extend up to 15 miles from a riverbank. Although the probability of flooding may be lower because a levee exists, risk is nonetheless still present. The American Society of Civil Engineers' publication "So, You Live Behind a Levee!" provides an in-depth explanation of levee and residual risk.



For more information about the risks associated with living behind levees, consult the publication "So, You Live Behind a Levee!" published by the American Society of Civil Engineers at http://content.asce.org/ASCELeveeGuide.html

- **Reasons levees are considered AoMIs:**
  - Like dams, many levees in the United States were constructed using unknown techniques and materials. These levees have a higher failure rate than those that have been designed to today's standards.
  - A levee might not provide the flood risk reduction it once did as a result of flood risk changes over time. Flood risk can change due to a number of factors, including increased flood levels due to climate change or better estimates of flooding, development in the watershed increasing flood levels and settlement of the levee or floodwall, and sedimentation in the levee channel. Increased flood levels mean decreased reduction of the flood hazard. The lack of adequate maintenance over time will also reduce the capability of a levee to contain the flood levels for which it was originally designed.

Canal levee breaches as a result of Hurricane Katrina in New Orleans in 2005. Note damages can be more extensive due to high velocity flood flows than if the levee was not there.

  - Given enough time, any levee will eventually be overtopped or damaged by a flood that exceeds the levee's capacity. Still, a widespread public perception of levees is that they will always provide protection. This perception may lead to not taking mitigation actions such as purchasing flood insurance.

- A levee is a system that can fail due to its weakest point, and therefore maintenance is critical. Many levees in the United States are poorly maintained or not maintained at all. Maintenance also includes maintaining the drainage systems behind the levees so they can keep the protected area dry.

- **Coastal Structures**

  Coastal structures, such as seawalls and revetments, are typically used to stabilize the shoreline to mitigate or prevent flood and/or erosion losses. Structures, such as jetties, groins and breakwaters, are constructed along naturally dynamic shorelines to alter the physical processes (e.g. sediment transport) for purposes that include reduction of long-term erosion rates, improvements to safe navigation (e.g., into ports), and reduction of erosive wave forces impacting a coast.

  - **Reasons coastal structures are considered AoMIs:**

    - Coastal structures may provide flood or erosion protection for one site. However, they may also interrupt the sediment transport process, resulting in accelerated coastal erosion downdrift of the structure.
    - Coastal structures are typically designed to withstand the forces associated with extreme design conditions of waves and water levels. Adequate protection may not be provided if these conditions are exceeded.
    - As with other infrastucture such as roads, bridges, and utilities, regular maintenance of shoreline protection structures is essential to ensure that they continue to provide the intended protection from flooding and erosion.

- **Stream Flow Constrictions**

  A stream flow constriction occurs when a human-made structure, such as a culvert or bridge, constricts the flow of a river or stream. The results of this constriction can be increased damage potential to the structure, an increase in velocity of flow through the structure, and the creation of significant ponding or backwater upstream of the structure. Regulatory standards regarding the proper opening size for a structure spanning a river or stream are not consistent and may be non-existent. Some local regulations require structures to pass a volume of water that corresponds to a certain size rain event; however, under sizing, these openings can result in flood damage to the structure itself. After a large flood event, it is not uncommon to have numerous bridges and culverts "washed out."

  - **Reasons stream flow constrictions are considered AoMIs:**

    - Stream flow constrictions can back water up on property upstream of the structure if not designed properly.
    - These structures can accelerate the flow through the structure causing downstream erosion if not properly mitigated. This erosion can affect the structure itself, causing undermining and failure.
    - If the constriction is a bridge or culvert, it can get washed out causing an area to become isolated and potentially more difficult to evacuate.

- Washed-out culverts and associated debris can wash downstream and cause additional constrictions.

- **At-Risk Essential Facilities**

  Essential facilities, sometimes called "critical facilities," are those whose impairment during a flood could cause significant problems to individuals or communities. For example, when a community's wastewater treatment is flooded and shut down, not only do contaminants escape and flow into the floodwaters, but backflows of sewage can contaminate basements or other areas of the community. Similarly, when a facility such as a hospital is flooded, it can result in a significant hardship on the community not only during the event but long afterwards as well.

  - **Reasons at-risk essential facilities are considered AoMIs:**
    - Costly and specialized equipment may be damaged and need to be replaced.
    - Impairments to facilities such as fire stations may result in lengthy delays in responding and a focus on evacuating the facility itself.
    - Critical records and information stored at these facilities may be lost.

- **Past Flood Insurance Claims and Individual Assistance/Public Assistance Hotspots**

  Assistance provided after flood events (flood insurance in any event and Individual Assistance [IA] or Public Assistance [PA] after declared disasters) occurs in flood affected areas. Understanding geographically where this assistance is being provided may indicate unique flood problems.

  Clusters of past flood insurance claims can show where there is a repetitive flood problem.

  Flood insurance claims are not always equally distributed in a community. Although estimates indicate that 20 to 50 percent of structures in identified flood hazard areas have flood insurance, clusters of past claims may indicate where there is a flood problem. However, clusters of past claims and/or areas where there are high payments under FEMA's IA or PA Programs may indicate areas of significant flood hazard.

  - **Reasons past claim hotspots are considered AoMIs:**
    - A past claim hotspot may reflect an area of recent construction (large numbers of flood insurance policies as a result of a large number of mortgages) and an area where the as-built construction is not in accordance with local floodplain management regulations.
    - Sometimes clusters of past claims occur in subdivisions that were constructed before flood protection standards were in place, places with inadequate stormwater management systems, or in areas that may not have been identified as SFHAs.

- Clusters of IA or PA claims may indicate areas where high flood insurance coverage or other mitigation actions are needed.

- **Areas of Significant Land Use Change**

  Development, whether it is a 100-lot subdivision or a single lot big box commercial outlet, can result in large amounts of fill and other material being deposited in flood storage areas, thereby increasing flood hazards downstream.

  Additionally, when development occurs, hard surfaces such as parking lots, buildings and driveways do not allow water to absorb into the ground, and more of the rainwater becomes runoff flowing directly into streams. As a result, the "peak flow" in a stream after a storm event will be higher and will occur faster. Without careful planning, major land use changes can affect the impervious area of a site and result in a significant increase in flood risk caused by streams that cannot handle the extra storm water runoff.

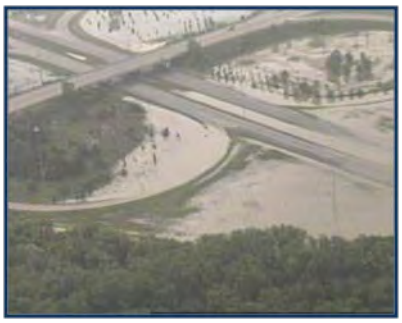
  Changes in land use in areas vulnerable to coastal flooding may affect the severity of wave hazards. Wave energy dissipates as waves propagate through forested areas or areas with dense development while wave energy can increase in open areas such as agricultural fields or parking lots. Changes in land use can affect wave hazards beyond the immediate area of land use change.

  Rooftops, pavements, patios, and driveways contribute to the impervious area in a watershed. This occurs in both urban areas and rural areas being developed.

  - **Reasons Areas of Significant Land Use Change are considered AoMIs:**
    - Development in areas mapped SFHA reduces flood storage areas, which can make flooding worse at the development site and downstream of it.
    - Impervious surfaces speed up the water flowing in the streams, which can increase erosion and the danger that fast-flowing floodwaters pose to people and buildings.
    - Open areas can allow wave energy to increase while densely developed areas and dense vegetation cover often obstruct waves. These obstructions diminish the wave's potentially destructive forces in areas inland of the obstructions.
    - Rezoning flood-prone areas to high densities and/or higher intensity uses can result in more people and property at risk of flooding and flood damage.

- **Key Emergency Routes Overtopped During Frequent Flooding Events**

  Roads are not always elevated above estimated flood levels, and present a significant flood risk to motorists during flooding events. When alternate routes are available, risks may be reduced, including risks to life and economic loss.



When large highways close due to flooding, traffic is detoured causing inconvenience and economic loss.

  - **Reasons overtopped roads are considered AoMIs:**
    - Such areas, when identified, can be accounted for and incorporated into Emergency Action Plans.
    - Roads may be elevated or reinforced to reduce the risk of overtopping during flood events.

- **Drainage or Stormwater-Based Flood Hazard Areas, or Areas Not Identified as Floodprone on the FIRM But Known to Be Inundated**

  Flood hazard areas exist everywhere. While FEMA maps many of these, others are not identified. Many of these areas may be located in communities with existing, older, and often inadequate stormwater management systems or in very rural areas. Other similar areas could be a result of complex or unique drainage characteristics. Even though they are not mapped, awareness of these areas is important so adequate planning and mitigation actions can be performed.

  - **Reasons drainage or stormwater-based flood hazard areas or unidentified floodprone locations are considered AoMIs:**
    - So further investigation of such areas can occur and, based on scientific data, appropriate mitigation actions can result (i.e., land use and building standards).
    - To create viable mitigation project applications in order to reduce flood losses.

- **Areas of Mitigation Success**

  Flood mitigation projects are powerful tools to communicate the concepts of mitigation and result in more resilient communities. Multiple agencies have undertaken flood hazard mitigation actions for decades. Both structural measures—those that result in flood control structures—and non-structural measures have been implemented in thousands of communities. An extensive list of mitigation actions can be found in Section 4.

  - **Reasons areas of mitigation success are considered AoMIs:**
    - Mitigation successes identify those areas within the community that have experienced a reduction or elimination of flood risk.

- Such areas are essential in demonstrating successful loss reduction measures and in educating citizens and officials on available flood hazard mitigation techniques.
- Avoided losses can be calculated and shown.

- **Areas of Significant Riverine or Coastal Erosion**

  Stream channels are shaped by a number of factors, including: degradation, aggradation, general scour, local scour, deposition, and lateral migration. Streams are constantly progressing towards a state of dynamic equilibrium involving water and sediment.

  Coastal shorelines erode in response to wave and water level conditions and other factors. As sea levels rise, erosion is typically exasperated.

  - **Reasons why areas of significant riverine or coastal erosion are considered AoMIs:**
    - Riverine flood damage assessments generally consider inundation alone
    - Bank erosion caused by within channel flows is not recognized as a significant hazard in Federal floodplain management regulations
    - Riverine and coastal erosion can undercut structures and roads, causing instability and possible collapse.
    - Landslides and mudslides are a result of erosion
    - Approximately one-third of the nation's streams experience severe erosion problems
    - Erosion of coastal barrier islands can result in breaches, washing out roads and cutting off access routes
    - Erosion often occurs along beaches during storms, especially severe storms that stay offshore for long durations and result in ongoing "battering" of the shoreline from high winds and waves. As the beach erodes, vulnerable properties are placed at even greater risk to coastal flooding from later storm surge, high tides, and wave action.

- **Other**

  Other types of flood risk areas include drainage or stormwater-based flood hazard areas, or areas known to be inundated during storm events.

3 Flood Risk Analysis Results

The following pages provide summary flood risk results for the Flood Risk Project as follows:

- **Flood Risk Map.** Within the Flood Risk Project the FRM displays base data reflecting community boundaries, major roads, and stream lines; potential losses that include both the 2010 Average Annualized Loss (AAL) flood loss study supplemented with new Hazus runs for areas with new or updated flood modeling; new Flood Risk Project areas; and graphics and text that promote access and usage of additional data available through the FRD, FIRM, and National Flood Hazard Layer and viewers (desktop or FEMA website, etc.). This information can be used to assist in Flood Risk Project-level planning as well as for developing mitigation actions within each jurisdiction located within the Flood Risk Project.

  The FRM provides a graphical overview of the Flood Risk Project which highlights areas of risk that should be noted, based on potential losses, exposed facilities, etc., based on data found in the FRD. Refer to the data in the FRD to conduct additional analyses.

- **Flood Risk Project Summary.** Within the Flood Risk Project area, summary data for some or all of the following datasets are provided for the entire project area and also on a jurisdiction by jurisdiction basis:
  - **Changes Since Last FIRM.** This is a summary of where the floodplain and flood zones have increased or decreased (only analyzed for areas that were previously mapped using digital FIRMs).
  - **Flood Depth and Analysis Grids.** A general discussion of the data provided in the FRD, including coastal analysis grids if furnished as part of the project.
  - **Flood Risk Assessments.** A loss estimation of potential flood damages from the 1-percent-annual-chance flood scenario.

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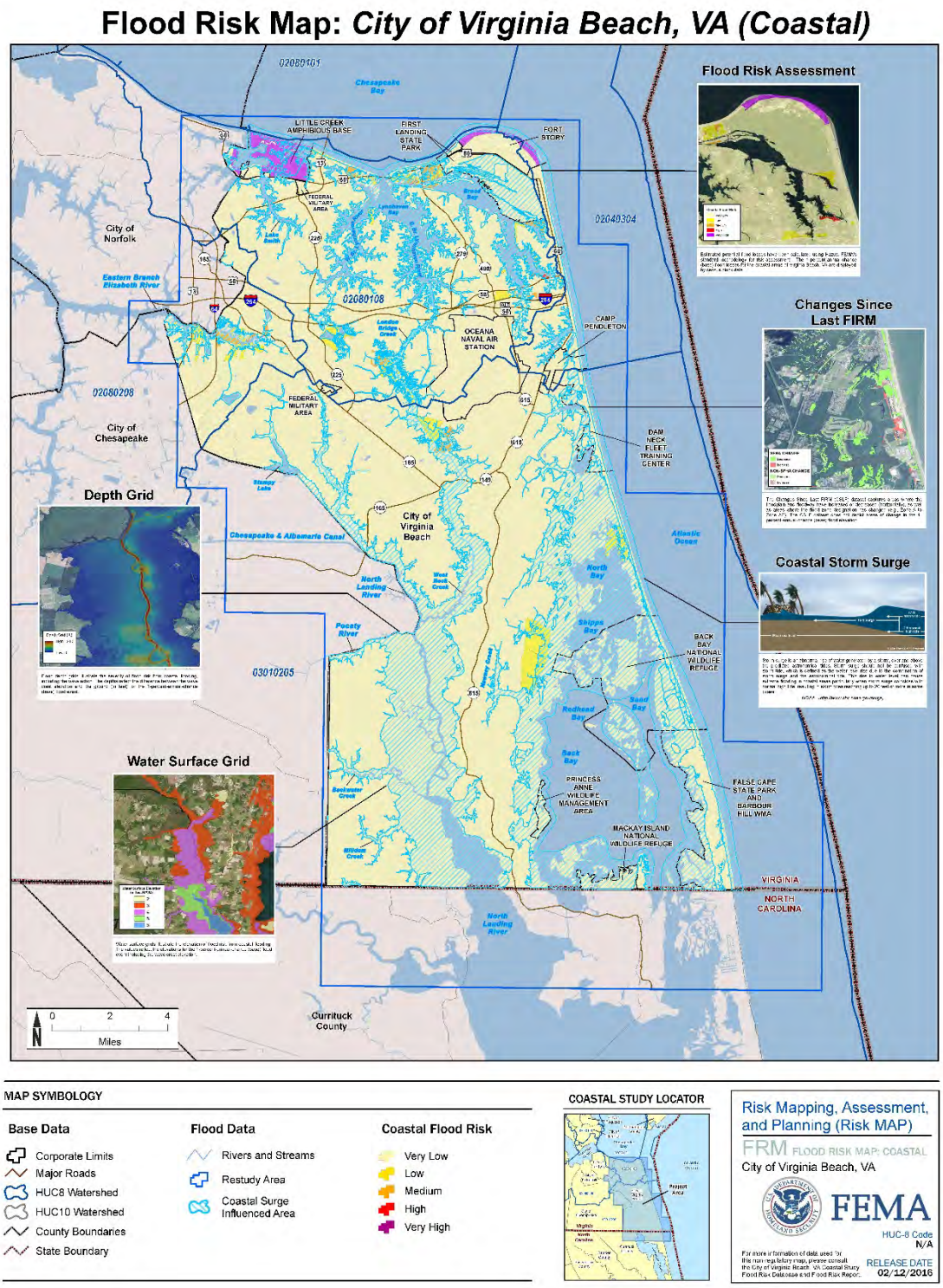
3.1 Flood Risk Map

The Flood Risk Map for this Flood Risk Project is shown below. In addition to this reduced version of the map, a full size version is available within the FRD.



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3.2 City of Virginia Beach, Virginia Coastal Study Summary

The following section provides an overview of the community's floodplain management program as of the date of this publication, and summarizes the coastal flood risk analysis performed for the City of Virginia Beach, Virginia.

3.2.1 Overview

The City of Virginia Beach is located in the southeastern corner of Virginia. It is bordered by the Atlantic Ocean to the east; the Chesapeake Bay to the north; the Cities of Norfolk and Chesapeake to the west; and the unincorporated areas of Currituck County, North Carolina to the south. Within the City are thousands of acres of farmland, five military installations, 28 miles of oceanfront, 10 miles of bay front, and 51.3 square miles of inland water. An arm of the Eastern Branch Elizabeth River enters the City from the west. In the southern part of the City are the broad expanses of Back Bay and Broad Bay. Important inland waterways include Rudee Inlet and Lake Holly, which are tidal inlets of the Atlantic Ocean, and Lynnhaven Bay, Broad Bay, Linkhorn Bay, and Little Creek, which are tidal estuaries of the Chesapeake Bay. Lake Smith and Stumpy Lake are sizable landlocked bodies of water within the City (FEMA, 2015).

The City enjoys a temperate climate with moderate seasonal changes. The climate is characterized by moderately warm summers with temperatures averaging 78 degrees Fahrenheit (ºF) in July, the warmest month. The winters are cool with temperatures averaging 41ºF in January, the coolest month. The average annual precipitation is approximately 45 inches. There is some variation in the monthly averages; however, rainfall is distributed evenly throughout the year. Snowfall is infrequent, generally occurring in light amounts which normally melt within 24 hours. Virginia Beach is situated in the Coastal Plain province and is underlain primarily by unconsolidated sand and clay strata. The terrain is essentially flat, with ground elevations averaging approximately 12 feet. Agriculture, Federal installations, and tourism are the mainstays of the City's economy. Most of the development in Virginia Beach has taken place in the northern half of the City. The southern half remains essentially rural, with farming the principal occupation. The local economy is also supported by medical fields, education, tourist industry, Federal installations, and some manufacturing (FEMA, 2015).

Community Name	CID	Total Community Population	Percent of Population in County (Coastal)	Total Community Land Area (sq mi)	Percent of Land Area in County (Coastal)	NFIP	CRS Rating	Mitigation Plan
City of Virginia Beach Independent City	515531	437,994	100	249.0	100	Y	10	Y

- Participating in the Southside Hampton Roads Hazard Mitigation Plan which expires February 13, 2017
- Past Federal Disaster Declarations for flooding in the City of Virginia Beach = 6
- National Flood Insurance Program (NFIP) policy coverage (policies/value) = 23,480 policies totaling approximately $6,242,583,400

- NFIP-recognized repetitive loss properties = 562
- NFIP-recognized severe repetitive loss properties = 118

Section 2 of the FRR provides more information regarding the source and methodology used to develop the information presented below. Datasets used toward the generation of results of this project are described in Section 7 of the FRR and are found in the FRD.

3.2.2 Flood Risk Datasets

As a part of this Coastal Flood Risk Project, flood risk datasets were created for inclusion in the Flood Risk Database. Those datasets are summarized for this Flood Risk Project below:

- **Changes Since Last FIRM**
  - Special Flood Hazard Area (SFHA) boundaries within the coastal regions of the City of Virginia Beach, Virginia Coastal Study were updated due to new engineering analysis performed within the Flood Risk Project. The updated modeling produced new flood zone areas and new base flood elevations and leveraged FEMA's recently developed LiDAR-based topographic data. Also, building data was provided by the City of Virginia Beach which was used to analyze changes in numbers of buildings in areas of change. The data in this section reflects the comparison between the effective FIRM(s) and the new analysis in this study.
  - The Changes Since Last FIRM data for this study has been calculated only for areas that fall within the updated coastal analysis.

    The table below summarizes the increases, decreases, and net change of the coastal SFHAs and Coastal High Hazard Areas (CHHAs) for the community.

Area of Study	Total Area (mi^2)	Increase (mi^2)	Decrease (mi^2)	Net Change (mi^2)
Within SFHA	116.7	2.0	9.4	-7.4
Within Floodway	0.0	0.0	0.0	0.0
Within CHHA (Zone VE or V)	17.1	11.6	0.5	11.1

Although the Flood Risk Database may contain Changes Since Last FIRM information outside of the City of Virginia Beach, Virginia, Coastal Study, the figures in this table only represent information within the City of Virginia Beach, Virginia Coastal Study.

Section 2 of the FRR provides more information regarding the source and methodology used to develop this table.

The table below summarizes the increases, decreases, and net change of coastal affected structures for the community.

Area of Study	# Buildings: Increase	# Buildings: Decrease	# Buildings: Net Change
Within SFHA	233	119	114
Within Floodway	0	0	0
Within CHHA (Zone VE or V)	4	1	3

Although the Flood Risk Database may contain Changes Since Last FIRM information outside of the City of Virginia Beach, Virginia, Coastal Study, the figures in this table only represent information within the City of Virginia Beach, Virginia Coastal Study.

Section 2 of the FRR provides more information regarding the source and methodology used to develop this table.

- Evidence of actual flood losses can be one of the most compelling factors for increasing a community's flood risk awareness.

- **Flood Depth and Analysis Grids**
  - See the FRD for the following depth and analysis grid data (Section 2 of the FRR provides general information regarding the development of and potential uses for this data):
    - Water surface elevation grid for the 1-percent-annual-chance flood event
    - Flood depth grid for the 1-percent-annual-chance flood event
  - Additional information and data layers provided within the FRD should be used to further isolate these and other areas where flood mitigation potential is high. The FRD includes data which may be helpful in planning and implementing mitigation strategies. Properties located in areas expected to experience some depth of water should seriously consider mitigation options for implementation.

- **Flood Risk Results**
  - The City of Virginia Beach, Virginia's coastal flood risk analysis incorporates results from a FEMA-performed Hazus analysis (Version 2.1 for 2010 AAL Study Data and Version 2.2 for Flood Risk Project Refined Data) which accounts for newly modeled areas in the Coastal Flood Risk Project and newly modeled depths for the 1-percent-annual-chance flood event. Potential losses were computed with community parcels, building footprints, and tax assessment data provided by the City of Virginia Beach to estimate loss ratios for the 1-percent-annual-chance flood scenario.
  - The following data layers provided within the FRD should be used to further analyze potential losses and areas where they are likely to occur.

National 2010 AAL Study Data

This set of features and tables in the FRD stores the default Hazus (Version 2.1) General Building Stock (GBS) inventory data (2000 census) and resulting losses from the FEMA National 2010 Average Annualized Loss (AAL) Study. These feature classes and data tables do not reflect any of the updates completed for this 'Refined' study.

- **S_CenBlk_Ar_2000** – This feature class contains the default Hazus GBS inventory data (2000 census) by 2000 census blocks. It is broken down by occupancy type (residential, commercial and other) and also by loss type (building and contents).
- **L_Exposure** – This table contains the default Hazus GBS inventory data (2000 census) by political area. It is broken down by occupancy type (residential, commercial, and other).
- **L_RA_AAL** – This table contains the results, by 2000 census block, of the FEMA National 2010 Hazus Level 1 AAL study. Hazus was used to generate depth grids for the 2-, 1-, 0.5- and 0.2-percent-annual-chance return periods. The loss analysis was completed for each return period using the default Hazus GBS inventory data (2000 census) by census block. The return period losses were used to calculate the AAL values.
- **L_RA_Summary** – This table contains a summary of the L_RA_AAL losses by political area. The loss ratio values are the percentage of the L_RA_AAL losses per L_Exposure values.

Flood Risk Project Refined Data

This set of feature classes and tables in the FRD stores the updated Hazus (Version 2.2) User-Defined Facilities (UDF) inventory data and resulting losses for this 'Refined' study. The same political area geometries were used so direct comparisons to the National 2010 AAL Study can be made. In order to more accurately represent the coastal flood risk in the county based on the current population distribution, Hazus loss estimates using the refined data are summarized by 2010 census block boundaries.

- **S_CenBlk_Ar_2010** – This feature class contains 2010 census block geometries and population counts. It can be used to examine Hazus flood losses that are summarized in the L_RA_Refined table.
- **S_UDF_Pt** – This feature class contains location and inventory data for site- specific risk assessments. Local data was obtained for this feature class, including building footprints, structure values and landuse classifications. The data was evaluated against the coastal 1-percent-annual-chance floodplain boundaries (presented on the countywide FIRM, effective January 16, 2015), and in areas where the actual building locations are contained in the SFHA, and were used as input in Hazus to calculate losses.

- **L_Exposure_Refined** – This table is an addition to the default database schema for this project. It contains a summary of S_UDF_Pt values (building+ contents value) by political area. It is broken down by occupancy type (residential, commercial, and other).

- **L_RA_Refined** – This table contains the results (by 2010 census block) of this flood risk study. Engineering models were used to generate depth grids for the 1-percent-annual-chance return period. The loss analysis was completed for the single return period using the updated Hazus UDF inventory data by 2010 census block. No AAL values were calculated since only a single return period losses were available.
- **L_RA_UDF_Refined** – This table is an addition to the default database schema for this project. It contains Hazus-estimated building and contents losses for all structures in the S_UDF_Pt feature class.
- **L_RA_Summary_Refined** – This table is an addition to the default database schema specifically for this project. It contains a summary of the L_RA_Refined losses by political area.
- **UDF_Hazus_Input** – This table is an addition to the default database schema specifically for this project. It contains the original UDF table that was imported into Hazus in order to run loss calculations.

Table 3-1: City of Virginia Beach, Virginia: Estimated Potential Losses for Flood Event Scenarios

Flood Risk Project Refined Losses[6]

Type	Inventory Estimated Value	% of Total	10% (10-Yr) Dollar Losses[1]	10% Loss Ratio[2]	2% (50-yr) Dollar Losses[1]	2% Loss Ratio[2]	1% (100-yr) Dollar Losses[1]	1% Loss Ratio[2]	0.2% (500-yr) Dollar Losses[1]	0.2% Loss Ratio[2]	Annualized Losses[1]($/yr)	Annualized Loss Ratio[2]
Residential Building & Contents	$553,500,000	21%	N/A	N/A	N/A	N/A	$24,500,000	N/A	N/A	N/A	N/A	N/A
Commercial Building & Contents	$330,900,000	12%	N/A	N/A	N/A	N/A	$1,200,000	N/A	N/A	N/A	N/A	N/A
Other Building & Contents	$1,762,200,000	67%	N/A	N/A	N/A	N/A	$14,700,000	N/A	N/A	N/A	N/A	N/A
Total Building & Contents[3]	**$2,646,600,000**	**100%**	**N/A**	**N/A**	**N/A**	**N/A**	**$40,400,000**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Business Disruption[4]	N/A	N/A	N/A	N/A	N/A	N/A	$3,500,000	N/A	N/A	N/A	N/A	N/A
TOTAL[5]	**$2,646,600,000**	**100%**	**N/A**	**N/A**	**N/A**	**N/A**	**$43,900,000**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

National 2010 AAL Study Losses[6]

Type	Inventory Estimated Value	% of Total	10% (10-Yr) Dollar Losses[1]	10% Loss Ratio[2]	2% (50-yr) Dollar Losses[1]	2% Loss Ratio[2]	1% (100-yr) Dollar Losses[1]	1% Loss Ratio[2]	0.2% (500-yr) Dollar Losses[1]	0.2% Loss Ratio[2]	Annualized Losses[1]($/yr)	Annualized Loss Ratio[2]
Residential Building & Contents	$33,493,000,000	75%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$32,200,000	<1%
Commercial Building & Contents	$8,110,600,000	18%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$8,600,000	<1%
Other Building & Contents	$3,319,900,000	7%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$3,400,000	<1%
Total Building & Contents[3]	**$44,923,600,000**	**100%**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**$44,300,000**	**<1%**
Business Disruption[4]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$600,000	N/A
TOTAL[5]	**$44,923,600,000**	**100%**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**$44,900,000**	**N/A**

[1]Losses shown are rounded to nearest $10,000 for values under $100,000 and to the nearest $100,000 for values over $100,000.
[2]Loss ratio = Dollar Losses ÷ Estimated Value. Loss Ratios are rounded to the nearest integer percent. Loss ratios were not calculated for the refined study because the analysis was restricted to parcels that were located in the coastal SFHA, which would result in highly skewed values.
[3]Total Building and Contents = Residential Building and Contents + Commercial Building and Contents + Other Building and Contents.
[4]Business Disruption = Inventory Loss + Relocation Cost + Income Loss + Rental Income Loss + Wage Loss + Direct Output Loss.
[5]Total = Total Building and Contents + Business Disruption.
[6] Flood Risk Project Refined losses calculated using Hazus Version 2.2, National 2010 AAL Study losses calculated using Hazus Version 2.1.
The figures in these tables only represent information within the City of Virginia Beach, Virginia Coastal Study.

4 Actions to Reduce Flood Risk

In order to fully leverage the Flood Risk Datasets and Products created for this Flood Risk Project, local stakeholders should consider many different flood risk mitigation tactics, including, but not limited the items shown in the sub-sections below.

4.1 Types of Mitigation Actions

Mitigation provides a critical foundation on which to reduce loss of life and property by avoiding or lessening the impact of hazard events. This creates safer communities and facilitates resiliency by enabling communities to return to normal function as quickly as possible after a hazard event. Once a community understands its flood risk, it is in a better position to identify potential mitigation actions that can reduce the risk to its people and property.

The mitigation plan requirements in 44 CFR Part 201 encourage communities to understand their vulnerability to hazards and take actions to minimize vulnerability and promote resilience. Flood mitigation actions generally fall into the following categories:

4.1.1 Preventative Measures

Preventative measures are intended to keep flood hazards from getting worse. They can reduce future vulnerability to flooding, especially in areas where development has not yet occurred or where capital improvements have not been substantial. Examples include:

- Comprehensive land use planning
- Zoning regulations
- Subdivision regulations
- Open space preservation
- Building codes
- Floodplain development regulations
- Stormwater management

Before Mitigation and After Mitigation

Communities will need to prioritize projects as part of the planning process. FEMA can then help route federal mitigation dollars to fund these projects.

NFIP's CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions meeting the three goals of the CRS: to reduce flood losses, to facilitate accurate insurance rating, and to promote the awareness of flood insurance.

For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount. (A Class 10 is not participating in the CRS and receives no discount.)

- Purchase development rights or conservation easements
- Participation in the NFIP Community Rating System (CRS)

4.1.2 Property Protection Measures

Property protection measures protect existing buildings by modifying the building to withstand floods, erosion, and waves or by removing buildings from hazardous locations. Examples include:

- Building relocation
- Acquisition and clearance
- Building elevation
- Barrier installation
- Building retrofit

4.1.3 Natural Resource Protection Activities

Natural resource protection activities reduce the impact of floods by preserving or restoring natural areas such as floodplains, wetlands, and dunes and their natural functions. Examples include:

- Wetland protection
- Habitat protection
- Erosion and sedimentation control
- Best management practices (BMP)
- Prevention of stream dumping activities (anti-litter campaigns)
- Improved forestry practices such as reforesting or selective timbering (extraction)
- Beach Nourishment
- Dune Construction
- Dune protection measures such as walkovers, sand fencing, and vegetation

4.1.4 Structural Mitigation Projects

Structural mitigation projects lessen the impact of floods by modifying the environmental natural progression of the flooding event. Structural protection such as upgrading dams/levees for already existing development and critical facilities may be a realistic alternative. However, citizens should be made aware of their residual risk. Examples include:

- Reservoirs, retention, and detention basins

- Levees and floodwalls
- Channel modifications
- Channel maintenance
- Seawalls, reventments, and bulkheads
- Groins, offshore breakwaters, and jetties

4.1.5 Public Education and Awareness Activities

Public education and awareness activities advise residents, business owners, potential property buyers, and visitors about floods, hazardous areas, and mitigation techniques they can use to reduce the flood risk to themselves and their property. Examples include:

- Readily available and readable updated maps
- Outreach projects
- Libraries
- Technical assistance
- Real estate disclosure
- Environmental education
- Risk information via the nightly news

For more information regarding hazard mitigation techniques, best practices, and potential grant funding sources, visit www.fema.gov or contact your local floodplain manager, emergency manager, or State Hazard Mitigation Officer.

4.1.6 Emergency Service Measures

Although not typically considered a mitigation technique, emergency service measures minimize the impact of flooding on people and property. These are actions commonly taken immediately prior to, during, or in response to a hazard event. Examples include:

- Hazard warning system
- Emergency response plan
- COOP and COG planning
- Critical facilities protection
- Health and safety maintenance
- Post flood recovery planning

4.2 Identifying Specific Actions for Your Community

As many mitigation actions are possible to lessen the impact of floods, how can a community decide which ones are appropriate to implement? There are many ways to identify specific actions most appropriate for a community. Some factors to consider may include the following:

- **Site characteristics.** Does the site present unique challenges (e.g., significant slopes or erosion potential)?
- **Flood characteristics.** Are the flood waters affecting the site fast or slow moving? Are there wave hazards? Is there debris associated with the flow? How deep is the flooding?
- **Social acceptance.** Will the mitigation action be acceptable to the public? Does it cause social or cultural problems?

Refer to FEMA Mitigation Planning How To Guide #3 (FEMA 386-3) "Developing the Mitigation Plan - Identifying Mitigation Actions and Implementation Strategies" for more information on how to identify specific mitigation actions to address hazard risk in your community.

- **Technical feasibility.** Is the mitigation action technically feasible (e.g., making a building watertight to a reasonable depth)?
- **Administrative feasibility.** Is there administrative capability to implement the mitigation action?
- **Legal.** Does the mitigation action meet all applicable codes, regulations, and laws? Public officials may have a legal responsibility to act and inform citizens if a known hazard has been identified.
- **Economic.** Is the mitigation action affordable? Is it eligible under grant or other funding programs? Can it be completed within existing budgets?
- **Environmental.** Does the mitigation action cause adverse impacts on the environment or can they be mitigated? Is it the most appropriate action among the possible alternatives?

FEMA in collaboration with the American Planning Association has released the publication, "Integrating Hazard Mitigation into Local Planning." This guide explains how hazard mitigation can be incorporated into several different types of local planning programs. For more information, go to www.planning.org or http://www.fema.gov/library.

Your local Hazard Mitigation Plan is a valuable place to identify and prioritize possible mitigation actions. The plan includes a mitigation strategy with mitigation actions that were developed through a public and open process. You can then add to or modify those actions based on what is learned during the course of the Risk MAP project and the information provided within this FRR.

4.3 Mitigation Programs and Assistance

Not all mitigation activities require funding (e.g., local policy actions such as strengthening a flood damage prevention ordinance), and those that do are not limited to outside funding sources (e.g., inclusion in local capital improvements plan, etc.). For those mitigation actions that require assistance through funding or technical expertise, several State and Federal agencies have flood hazard mitigation grant programs and offer technical assistance. These programs may be funded at different levels over time or may be activated under special circumstances such as after a presidential disaster declaration.

Communities can link hazard mitigation plans and actions to the right FEMA grant programs to fund flood risk reduction. More information about FEMA HMA programs can be found at http://www.fema.gov/government/grant/hma/index.shtm.

4.3.1 FEMA Mitigation Programs and Assistance

FEMA awards many mitigation grants each year to states and communities to undertake mitigation projects to prevent future loss of life and property resulting from hazard impacts, including flooding. The FEMA Hazard Mitigation Assistance (HMA) programs provide grants for mitigation through the programs listed in Table 4-1 below.

Table 4-1. FEMA Hazard Mitigation Assistance Programs

Mitigation Grant Program	Authorization	Purpose
Hazard Mitigation Grant Program (HMGP)	Robert T. Stafford Disaster Relief and Emergency Assistance Act	Activated after a presidential disaster declaration; provides funds on a sliding scale formula based on a percentage of the total federal assistance for a disaster for long-term mitigation measures to reduce vulnerability to natural hazards
Flood Mitigation Assistance (FMA)	National Flood Insurance Reform Act	Reduce or eliminate claims against the NFIP
Pre-Disaster Mitigation (PDM)	Disaster Mitigation Act	National competitive program focused on mitigation project and planning activities that address multiple natural hazards
Repetitive Flood Claims (RFC)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	Reduce flood claims against the NFIP through flood mitigation; properties must be currently NFIP insured and have had at least one NFIP claim
Severe Repetitive Loss (SRL)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	Reduce or eliminate the long-term risk of flood damage to SRL residential structures currently insured under the NFIP

The HMGP and PDM programs offer funding for mitigation planning and project activities that address multiple natural hazard events. The FMA, RFC, and SRL programs focus funding efforts on reducing claims against the NFIP. Funding under the HMA programs is subject to availability of annual appropriations, and HMGP funding is also subject to the amount of FEMA disaster recovery assistance provided under a presidential major disaster declaration.

FEMA's HMA grants are awarded to eligible states, tribes, and territories (applicant) that, in turn, provide sub-grants to local governments and communities (sub-applicant). The applicant selects and prioritizes sub-applications developed and submitted to them by sub-applicants and submits them to FEMA for funding consideration. Prospective sub-applicants should consult the office designated as their applicant for further information regarding specific program and application requirements. Contact information for the FEMA Regional Offices and State Hazard Mitigation Officers (SHMO) is available on the FEMA website (www.fema.gov).

4.3.2 Additional Mitigation Programs and Assistance

Several additional agencies including USACE, Natural Resource Conservation Service (NRCS), U.S. Geological Survey (USGS), NOAA, and others have specialists on staff and can offer further information on flood hazard mitigation. The State NFIP Coordinator and SHMO are state-level sources of information and assistance, which vary among different states.

The Silver Jackets program, active in several states, is a partnership of USACE, FEMA, and state agencies. The Silver Jackets program provides a state-based strategy for an interagency approach to planning and implementing measures for risk reduction.

5 Acronyms and Definitions

5.1 Acronyms

A

AAL	Average Annualized Loss
ALR	Annualized Loss Ratio
AoMI	Areas of Mitigation Interest

B

BCA	Benefit-Cost Analysis
BFE	Base Flood Elevation
BMP	Best Management Practices

C

CFR	Code of Federal Regulations
CID	Community Identification Number
COG	Continuity of Government Plan
COOP	Continuity of Operations Plan
CRS	Community Rating System
CSLF	Changes Since Last FIRM

D

DHS	Department of Homeland Security
DMA 2000	Disaster Mitigation Act of 2000

E

EOP	Emergency Operations Plan

F

FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FRD	Flood Risk Database
FRM	Flood Risk Map
FRR	Flood Risk Report
FY	Fiscal Year

G

GIS	Geographic Information System

H

HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program

I

IA	Individual Assistance

N

NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NRCS	Natural Resource Conservation Service

P

PA	Public Assistance
PDM	Pre-Disaster Mitigation

R

RFC	Repetitive Flood Claims
Risk MAP	Mapping, Assessment, and Planning

S

SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SRL	Severe Repetitive Loss

T

TEIF	Total Exposure in Floodplain

U

USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

5.2 Definitions

0.2-percent-annual-chance flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year. Sometimes referred to as the 500-year flood.

1-percent-annual-chance flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year. Sometimes referred to as the 100-year flood.

Accredited Levee System – A levee system that FEMA has shown on a FIRM that is recognized as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood. This determination is based on the submittal of data and documentation as required by 44CFR65.10 of the NFIP regulations. The area landward of an accredited levee system is shown as Zone X (shaded) on the FIRM except for areas of residual flooding, such as ponding areas, which are shown as Special Flood Hazard Area (SFHA).

Annualized Loss Ratio (ALR) – Expresses the annualized loss as a fraction of the value of the local inventory (total value/annualized loss).

Average Annualized Loss (AAL) – The estimated long-term weighted average value of losses to property in any single year in a specified geographic area.

Base Flood Elevation (BFE) – Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.

Berm – A small levee, typically built from earth.

Cfs – Cubic feet per second, the unit by which discharges are measured (a cubic foot of water is about 7.5 gallons).

Coastal High Hazard Area (CHHA) – Portion of the SFHA extending from offshore to the inland limit of a primary frontal dune along an open coast or any other area subject to high velocity wave action from storms or seismic sources.

Consequence (of flood) – The estimated damages associated with a given flood occurrence.

Crest – The peak stage or elevation reached or expected to be reached by the floodwaters of a specific flood at a given location.

Dam – An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Design flood event – The greater of the following two flood events: (1) the base flood, affecting those areas identified as SFHAs on a community's FIRM; or (2) the flood corresponding to the area designated as a flood hazard area on a community's flood hazard map or otherwise legally designated.

Erosion – Process by which floodwaters lower the ground surface in an area by removing upper layers of soil.

Essential facilities – Facilities that, if damaged, would present an immediate threat to life, public health, and safety. As categorized in Hazus, essential facilities include hospitals, emergency operations centers, police stations, fire stations, and schools.

Flood – A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters or (2) the unusual and rapid accumulation or runoff of surface waters from any source.

Flood Insurance Rate Map (FIRM) – An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community. See also Digital Flood Insurance Rate Map.

Flood Insurance Study (FIS) Report – Contains an examination, evaluation, and determination of the flood hazards of a community, and if appropriate, the corresponding water-surface elevations.

Flood risk – Probability multiplied by consequence; the degree of probability that a loss or injury may occur as a result of flooding. This is sometimes referred to as flood vulnerability.

Flood vulnerability – Probability multiplied by consequence; the degree of probability that a loss or injury may occur as a result of flooding. This is sometimes referred to as flood risk.

Flood-borne debris impact – Floodwater moving at a moderate or high velocity can carry flood-borne debris that can impact buildings and damage walls and foundations.

Floodwall – A long, narrow concrete or masonry wall built to protect land from flooding.

Floodway (regulatory) – The channel of a river or other watercourse and that portion of the adjacent floodplain that must remain unobstructed to permit passage of the base flood without cumulatively increasing the water surface elevation more than a designated height (usually 1 foot).

Floodway fringe – The portion of the SFHA that is outside of the floodway.

Freeboard – A factor of safety usually expressed in feet above a flood level for purposes of flood plain management. “Freeboard” tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed (44CFR§59.1).

Hazus – A GIS-based risk assessment methodology and software application created by FEMA and the National Institute of Building Sciences for analyzing potential losses from floods, hurricane winds and storm surge, and earthquakes.

High velocity flow – Typically comprised of floodwaters moving faster than 5 feet per second.

Levee – A human-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding. (44CFR§59.1)

Loss ratio – Expresses loss as a fraction of the value of the local inventory (total value/loss).

Mudflow – Mudslide (i.e., mudflow) describes a condition where there is a river, flow or inundation of liquid mud down a hillside usually as a result of a dual condition of loss of brush cover, and the subsequent accumulation of water on the ground preceded by a period of unusually heavy or sustained rain. A mudslide (i.e., mudflow) may occur as a distinct phenomenon while a landslide is in progress, and will be recognized as such by the Administrator only if the mudflow, and not the landslide, is the proximate cause of damage that occurs. (44CFR§59.1)

Non-Accredited Levee System – A levee system that does not meet the requirements spelled out in the NFIP regulations at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44CFR65.10), Mapping of Areas Protected by Levee Systems, and is not shown on a FIRM as reducing the flood hazard posed by a 1-percent-annual-chance flood.

Primary frontal dune (PFD) – A continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms.

The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.

Probability (of flood) – The likelihood that a flood will occur in a given area.

Provisionally Accredited Levee (PAL) – A designation for a levee system that FEMA has previously accredited with reducing the flood hazards associated with a 1-percent-annual-chance or greater flood on an effective FIRM, and for which FEMA is awaiting data and/or documentation that will demonstrate the levee system's compliance with the NFIP regulatory criteria cited at 44CFR65.10.

Risk MAP – Risk Mapping, Assessment, and Planning, a FEMA strategy to work collaboratively with state, local, and tribal entities to deliver quality flood data that increases public awareness and leads to action that reduces risk to life and property.

Riverine – Of, or produced by, a river. Riverine floodplains have readily identifiable channels.

Special Flood Hazard Area (SFHA) – Portion of the floodplain subject to inundation by the 1-percent-annual or base flood.

Stafford Act – Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288. This Act constitutes the statutory authority for most federal disaster response activities especially as they pertain to FEMA and FEMA programs.

Stillwater – Projected elevation that flood waters would assume, referenced to National Geodetic Vertical Datum of 1929, North American Vertical Datum of 1988, or other datum, in the absence of waves resulting from wind or seismic effects.

Stream Flow Constrictions – A point where a human-made structure constricts the flow of a river or stream.

Total Exposure in Floodplain - An analysis of the total potential economic losses (exposure) in the Special Flood Hazard Area (SFHA).

6 Additional Resources

ASCE 7 – National design standard issued by the American Society of Civil Engineers (ASCE), *Minimum Design Loads for Buildings and Other Structures*, which gives current requirements for dead, live, soil, flood, wind, snow, rain, ice, and earthquake loads, and their combinations, suitable for inclusion in building codes and other documents.

ASCE 24-05 – National design standard issued by the ASCE, *Flood Resistant Design and Construction*, which outlines the requirements for flood resistant design and construction of structures in flood hazard areas.

National Flood Insurance Program (NFIP), Federal Emergency Management Agency (FEMA), www.floodsmart.gov

FEMA, www.fema.gov

FEMA, *Guidelines and Standards for Flood Risk Analysis and Mapping*, www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping

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FEMA, 2007c. *Public Assistance Guide*, FEMA 322. Washington, DC, June 2007.

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FEMA, 2007f. *Selecting Appropriate Mitigation Measures for Floodprone Structures*, FEMA 551. Washington, DC, March 2007.

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7 Data Used to Develop Flood Risk Products

Engineering study information was leveraged from Risk Assessment, Mapping, and Planning Partners (RAMPP) with coordination from FEMA Region III and the U.S. Army Corps of Engineers (USACE).

AAL data was based on FEMA's National Hazus Level 1 analysis, published in 2010. This data has limited distribution and can be made available upon request.

Flood Insurance Claim/Policy/Repetitive Loss and Hazard Mitigation Plan information were acquired from FEMA.

Photos shown on the Flood Risk Map were taken from publically available sources on the Internet.

Parcel, building footprint, and tax assessment data (March 2015) acquired from the City of Virginia Beach.

HUC boundaries were provided by the U.S. Department of Agriculture (USDA).

GIS basemap information was acquired from the Preliminary FIS DFIRM database before it became effective. The Effective DFIRM database is available for download from the FEMA Map Service Center at http://msc.fema.gov/portal. The data is posted within Effective Products under the *NFHL-Data County* directory, effective January16, 2015.

Census and land information were acquired from the U.S. Census Bureau. Population data reported is based on the 2010 census. As such, there may be minor discrepancies in the FRD when comparing census blocks to communities to arrive at total population.

Changes Since Last FIRM (CSLF) are provided both for the project area, only as summarized in this Flood Risk Report, as developed for the most recent map revision of the Flood Insurance Rate Map (FIRM). All data was digitally captured from the previously effective maps.

Hillshade, also known as Shaded Relief is shown on the background of the Flood Risk Map. It is a cartographic process of 3-D visualization of the terrain on maps and charts that implements graded shadows created by light shining from the north-west direction. These data were acquired from the USGS. This data layer is called a "Hillshade" in the Flood Risk Database.